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REPORT NO. NAEC-AML-1758

VAPOR LUBRICATION OF HIGH SPEED BALL BEARINGS

PROBLEM ASSIGNMENT NO. C 03 RMA 42-14 UNDER BUREAU OF NAVAL WEAPONS
WEPTASK RRMA 04 014/200 1/R001 07 01

A. Object

To investigate volatile organic solids for use as gaseous lubricants and to determine the effect of chemical composition for bearing component metals in vapor lubrication.

B. Details

Initial experiments described in Report No. NAMC-AML-1552 showed that the vapors of volatile amine carbamate type compounds provided effective lubrication for high speed ball bearings at elevated temperatures. These experiments have been continued to include other classes of volatile organic solids i.e., aromatic halogens, amines, hydrocarbons and terpenes. The following compounds have exhibited lubricating properties: naphthalene, durene, camphene, and p-toluidine. Corrosion of the test bearing during shutdown periods is considered to be a cause of short bearing life when using chlorinated aromatic compounds. Additional experiments including continuous running at elevated temperatures are being conducted with this class of compounds. Results of the performance tests are shown in Table I. The volatile material is carried to the bearing using nitrogen gas. A limited number of runs using argon gas in place of nitrogen gas showed a reduced running time to failure for three different compounds. The bearing housing design and test apparatus have been described in the aforementioned report.

In addition, the response of naphthalene and morpholine carbamate to metal surfaces of different composition was investigated to provide information on the mechanism of lubrication for the volatile compounds. Several possible mechanisms are projected including: chemical adsorption, physical adsorption, decomposition of the volatile compound yielding an oily substance and chelation reactions between vapor and bearing metal. AISI 1010 steel, silver plated 1010 steel and nickel plated 1010 steel as retainer specimens have shown a higher level of susceptibility to vapor lubrication compared to chromium plated 1010 steel and cadmium plated 1010 steel. Data covering test runs is shown in Table II. These data establish the significance of the chemical composition of the bearing metal in the vapor lubrication process. Additional experiments will be required to determine the mechanism of lubrication for the volatile solids under study.

C. Future Work

Future work will include the following:

1. Continued investigation of new compounds as gaseous lubricants.

2. Investigation of the susceptibility of different metals and alloys for vapor lubrication.

3. High temperature performance tests at 750°F.

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Table I - Results of Vapor Lubrication Experiments

Table II - Effect of Bearing Metallurgy on Performance of Vapor Phase Lubricants

TABLE 1

RESULTS OF VAPOR LUBRICATION EXPERIMENTS

Apparatus: High Speed, High Temperature Bearing Test Apparatus

Speed: 10,000 RPM

Bearing Specimen: 204 Size Ball Bearings. Races and Balls: AISI 52100, Retainer:. AISI 1010

Flow Rate - (Carrier Gas): 0.08 Cu.Ft./Min.

Organic Solid	Carrier Gas	Test Temperature	Running Time (Hours)
p-Dichlorobenzene	N_2	250°F	31+, 28, 20
p-Chlorophenol	N_2	200°F	102
p-Chlorophenol	N_2	250°F	3.7
2-4-Dichlorophenol	N_2	200°F	16
2-4-Dichlorophenol	N_2	250°F	27, 15, 16, 95
Naphthalene	N_2	250°F	309+
Naphthalene	Argon	250°F	1.5, 42
Camphene	N_2	250°F	290+
Camphene	N_2	350°F	153+
Camphor	N_2	250°F	123
Camphor	Argon	250°F	7, 23
Durene	N_2	250°F	22, 449
Benzoic Acid	N_2	250°F	0.4, 0.1
Cyclohexylamine	N_2	250°F	70+, 140+
Cyclohexylamine	Argon	250°F	0.1, 0.2
p-Toluidine	N_2	250°F	690
p-Toluidine	N_2	300°F	324
2-Methyl-Piperidine + CO_2 Reaction Product	N_2	250°F	53

TABLE 2

EFFECT OF BEARING METALLURGY ON PERFORMANCE OF VAPOR PHASE LUBRICANTS

Apparatus: High Speed High Temperature Bearing Test Apparatus

Test Specimen: 204 Size Ball Bearing, AISI 52100 Balls and Races, Retainer - As shown.

Speed: 10,000 RPM

Temperature: 250°F

Load: 5 LB.-Thrust 3 LB.-Radial

Retainer Composition	Plating	Running Time	
		Morpholine Carbamate	Naphthalene
AISI-1010 Steel	None	130,133	309+
AISI-1010 Steel	Silver	61[illegible],248	141
AISI-1010 Steel	Nickel	366,[illegible]09	.1
AISI-1010 Steel	Chromium	11.5	.1
AISI-1010 Steel	Cadmium	1	0.0
24ST Aluminum	None	39	___
Cast Iron	None	100+, 157	___